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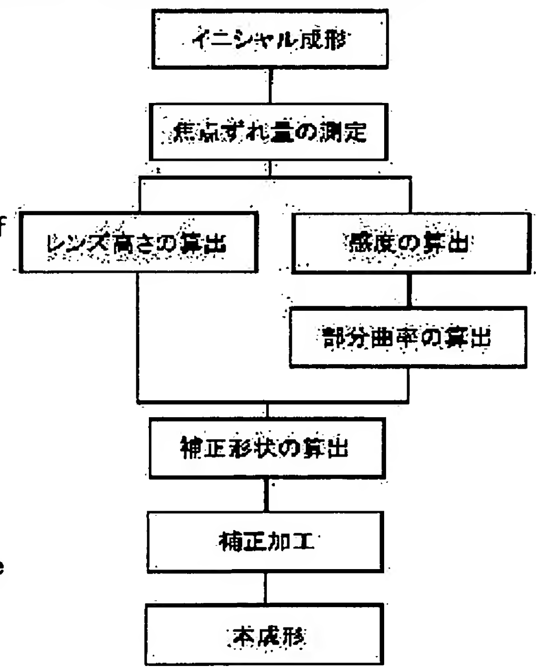
## (54) OPTICAL ELEMENT AND ITS MANUFACTURING METHOD AS WELL AS OPTICAL SCANNER




(57)Abstract:
PROBLEM TO BE SOLVED: To enable an optical element for an optical scanner for reducing an image surface curved surface generated by shifting of focus on an image surface to be manufactured in a short time at a low cost.
SOLUTION: A method for manufacturing the optical element comprises a step of measuring a shift of focus each of a plurality of image heights in an optical axis direction on the image surface by mounting the injection molded optical element in the optical scanner equivalent to that at its using time, a lens height calculating step of obtaining a position on a specific optical functional surface corresponding to each of the plurality of the image heights, a step of calculating a sensitivity of a proportional coefficient of the shift of focus to a partial curvature of the specific optical functional surface corresponding to each of the plurality of the image heights, a step of obtaining the partial curvature at the specific optical functional surface according to the defocusing amount and the sensitivity, a correcting shape calculating step of outputting the correcting shape of the optical functional surface as a coefficient of a functional model or map date based on the lens heights and the partial curvature, a step of correcting the shape of a specular partition corresponding to the specific optical functional surface of a mold for molding according to the correcting shape, and a step of molding the corrected specular partition.

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CLAIMS

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[Claim(s)]
[Claim 1] In the manufacture approach of the optical element which creates with shaping the optical element used by light-scanning optical system The amount measurement process of focal gaps which attaches the optical element by which injection molding was carried out in light-scanning equipment equivalent to the time of use, and measures the amount of focal gaps of the direction of an optical axis in two or more image quantities in the image surface, The lens height calculation process of asking for the location on the specific optical functional side corresponding to two or more image quantities, The sensibility calculation process which computes the sensibility which is the partial curvature of a specific optical functional side and the proportionality coefficient of the amount of focal gaps corresponding to two or more image quantities, The above-mentioned amount of focal gaps, and the partial curvature calculation process of asking for the partial curvature in respect of a specific optical function from the above-mentioned sensibility, The above-mentioned lens height and the amendment configuration calculation process which outputs the amendment configuration of an optical functional side as the multiplier or map data of a function model based on partial curvature, The manufacture approach of the optical element characterized by consisting of an amendment processing process which carries out amendment processing of the configuration of the mirror plane piece corresponding to the specific optical functional side of a molding die according to the above-mentioned amendment configuration, and a forming cycle which fabricates by the mirror plane piece by which amendment processing was carried out.
[Claim 2] The manufacture approach of the optical element according to claim 1 which carries out the description of performing the above-mentioned focal gap measurement process using the optical element which consists of the above-mentioned forming cycle, and performing from the above-mentioned lens height calculation process to a forming cycle repeatedly when this does not fulfill the target.
[Claim 3] The lens height whose above-mentioned lens height calculation process is the location of the main scanning direction which intersects the optical functional side of specification [ a chief ray ] by two or more deflection angles by optical simulation beforehand, The manufacture approach of the optical element of claim 1 characterized by asking for the image quantity which is the location of the main scanning direction which intersects the image surface, approximating this distribution to models, such as a polynomial, memorizing that multiplier, and computing the lens height corresponding to the image quantity which is an input by solving a polynomial, or claim 2.
[Claim 4] The above-mentioned sensibility calculation process makes a configuration error superimpose only on a specific optical functional side by optical simulation beforehand. By two or more deflection angles Image quantity, It asks for the amount of focal gaps of the direction of an optical axis, and the partial curvature of the flux of light passage part in a specific optical functional side. Do the division of the amount of focal gaps with partial curvature, and it asks for the sensibility of the amount of focal gaps per unit curvature. The manufacture approach of the optical element of claim 1 characterized by approximating distribution of image quantity and sensibility to function models, such as a polynomial, memorizing the multiplier, and computing the sensibility corresponding to the image quantity which is an input by solving a function model thru/or claim 3.
[Claim 5] The above-mentioned amendment configuration calculation process approximates distribution of lens height and the partial curvature of the direction of vertical scanning to a function model. Memorize the multiplier and it asks for partial curvature by solving a function model from the location of the main scanning direction in two or more points of an optical functional side. The manufacture approach of the optical element of claim 1 characterized by consisting of a configuration calculation process of finding height by solving the

formula of the radii function which has the above-mentioned partial curvature from the location of the direction of vertical scanning thru/or claim 4.
[Claim 6] The above-mentioned amendment configuration calculation process is distribution of lens height and the partial curvature of vertical scanning.

$$C_s = \sum_{i=0}^{n} C_{si} x^i$$

Resemble the becoming polynomial and use this multiplier Csi.

$$z(x,y) = \sum_{i=0}^{n} \frac{C_{si}}{2} x^i y^2$$

The manufacture approach of the optical element of claim 1 characterized by computing the amendment configuration in the point of arbitration by solving the becoming formula thru/or claim 4.
[Claim 7] the manufacture approach of the optical element of claim 1 characterize by for the above-mentioned amendment configuration calculation process to consist of a modeling process which resemble a function model to distribution of lens height and the partial curvature of a main scanning direction , integrate with a function model twice , and memorize the multiplier , and a configuration calculation process of find height by solve a function model from the location of the main scanning direction in two or more points of an optical functional side thru/or claim 6 .
[Claim 8] A numerical-integration process [ as opposed to / the above-mentioned amendment configuration calculation process performs numerical integration twice to distribution of lens height and the partial curvature of a main scanning direction, and / distribution of lens height and height ], The manufacture approach of the optical element of claim 1 characterized by consisting of a modeling process which approximates this to a function model and memorizes the multiplier, and a configuration calculation process of finding height by solving a function model from the location of the main scanning direction in two or more points of an optical functional side thru/or claim 6.
[Claim 9] The optical element characterized by being created by the manufacture approach of the optical element for light-scanning equipments of claim 1 thru/or claim 8.
[Claim 10] The optical element of claim 9 which at least one optical functional side is an abbreviation flat surface, and is characterized by making this field into the above-mentioned specific optical functional side.
[Claim 11] Light-scanning equipment characterized by using the optical element of claim 9 and claim 10.
[Claim 12] Are the program which creates NC data for processing the mirror plane piece corresponding to the optical functional side of the metal mold for plastics injection molding with a NC machining machine, and the measurement result of the amount of focal gaps in two or more image quantities which can be set to the image surface of light-scanning equipment is used as input data. A lens height calculation means to compute the lens height of the specific optical functional side corresponding to the image quantity of arbitration, A lens height calculation means to compute the sensibility which is the partial curvature of a specific optical functional side and the proportionality coefficient of the amount of focal gaps corresponding to the image quantity of arbitration, NC creation program characterized by consisting of the amount of focal gaps, a partial curvature calculation means to compute partial curvature from sensibility, and lens height and an amendment configuration calculation means to compute NC data for amendment processing of a specific mirror plane piece from distribution of partial curvature.

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[Translation done.]

* NOTICES *

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention is used for evaluation of the optical element in the equipment of digital KOPIA or a laser beam printer write-in [ optical ] about an optical element, its manufacture approach, especially the optical element for light-scanning equipments, and is effective.
[0002]
[Description of the Prior Art] The light-scanning equipment using a laser light source and a polyhedron mirror is used for digital KOPIA or a laser beam printer. An example of light-scanning equipment is shown in drawing 2 R> 2. The flux of light which carried out outgoing radiation from the light sources 1, such as semiconductor laser, penetrates a collimator lens 2, turns into the parallel flux of light, penetrates the cylinder side lens 3, and is condensed by the line on the reflector of the polyhedron mirror 4. The flux of light which responded to rotation of a polyhedron mirror, and was reflected and deflected condenses on the photo conductor front face which penetrated the scan optical system 5 and was installed in the image surface 6. Here, the location of a main scanning direction [ in / for the location of a main scanning direction / in / for the direction which intersects perpendicularly the direction which deflects the flux of light in a polyhedron mirror in a main scanning direction, a main scanning direction, and the direction of an optical axis / the direction of vertical scanning and each optical functional side / lens height and the image surface ] is described to be image quantity. In order to meet the demand of high-definition-izing in recent years, and the demand of wanting to reduce the number of the optical elements of scan optical system for low-cost-izing, the curved surface where a degree of freedom is high has come to be used for the configuration of the optical functional side of the optical element of scan optical system. A special toric side where curvature especially changes the aspheric surface with main scanning directions in the direction of vertical scanning in a main scanning direction has been used more often. The example is shown below.

$$z(x,y)=\frac{Cx^2}{1+\sqrt{1-(1+k)C^2x^2}}+\sum_{j=0}^{m}\sum_{i=0}^{n}e_{ji}x^iy^j$$

Here, for the coordinate of the direction of vertical scanning, and z, the coordinate of the direction of an optical axis and c are [ the coordinate and y whose x is a main scanning direction / a cone constant and eji of the curvature of a main scanning direction and k ] the multipliers of a polynomial. By utilization of an ultraprecise free sculptured surface processing machine, the field where such a degree of freedom is high can be adopted now as an optical functional side.
[0003] In the direction of vertical scanning, it is carrying out flat [ of the scope of each optical functional side of scan optical system ] to the main scanning direction 10mm order to being in hundreds of mm from dozens of mm. When creating such an optical element with plastics injection molding etc., the deflection (this is called a "configuration error" below) from a design value occurs under the effect of uneven contraction of resin etc. In creating the mirror plane piece for injection molding from the design configuration of an optical functional side, since it was about 0.7% in general, contraction of resin had processed the configuration which carried out similarity expansion with contraction searched for conventionally theoretically or experientially. However, hundreds of mm and the configuration error of the optical functional side by nonlinear contraction of resin since it is large are set to several micrometers to dozens of micrometers, this is large for the engine performance of

optical system, and an optical functional side influences.
[0004] As one of the approaches of making the configuration error of mold goods small, the configuration of mold goods is measured as indicated by JP,5-96572,A and JP,7-60857,A, a configuration error is searched for, and there is the approach of amending the mirror plane piece of a die so that this may be offset. However, now, it is necessary to amend the mirror plane piece corresponding to all optical functional sides until a configuration error becomes sufficiently small.
[0005] Moreover, there is a problem (bibliography: JP,10-288749,A, JP,11-77842,A) of refractive-index distribution as a description of the lens created with plastics injection molding. Uneven distribution of the refractive index in resin induces the lens effectiveness, this is the phenomenon of changing the focal location of optical system, in order to avoid this, needs to devise to a design or needs to establish the process for decreasing refractive-index distribution after shaping. Moreover, unless this is made to 0, even if it creates all optical elements in the configuration as a design value, as light-scanning equipment, degradation of optical-character ability will be produced by the curvature of field by gap of a focal location.
[0006] Although it is necessary to make the f number of optical system small since the diameter of a spot carries out proportionally [ abbreviation ] at the f number of optical system when making small the diameter of a spot in the image surface and creating the scan optical system of the equipment of high density write-in [ optical ] especially, it will carry out proportionally [ abbreviation ] and the depth of focus will become narrow at the square of the diameter of a spot at coincidence. Therefore, in order to develop the small light-scanning equipment of the diameter of a spot, there is the need of making small enough the curvature of field produced by the focal gap by the image surface, and this has been a big technical technical problem to implementation of the light-scanning equipment of high density.
[0007]
[Problem(s) to be Solved] Then, this invention makes it that technical problem to devise that manufacture approach and manufacturing installation so that the small optical element for thing light-scanning equipments of a curvature of field can be manufactured by the short time and low cost, as the curvature of field produced by the focal gap by the image surface can be made small enough.
[0008]
[The means provided for technical-problem solution]
[Solution means 1] (It corresponds to claim 1) The solution means 1 consists of following processes on the assumption that the manufacture approach of the optical element which creates with shaping the optical element used by light-scanning optical system. The amount measurement process of focal gaps which attaches the optical element by which injection molding was carried out in light-scanning equipment equivalent to the time of use, and measures the amount of focal gaps of the direction of an optical axis in two or more image quantities in the image surface, The lens height calculation process of asking for the location on the specific optical functional side corresponding to two or more image quantities, The sensibility calculation process which computes the sensibility which is the partial curvature of a specific optical functional side and the proportionality coefficient of the amount of focal gaps corresponding to two or more image quantities, The above-mentioned amount of focal gaps, and the partial curvature calculation process of asking for the partial curvature in respect of a specific optical function from the above-mentioned sensibility, The above-mentioned lens height and the amendment configuration calculation process which outputs the amendment configuration of an optical functional side as the multiplier or map data of a function model based on partial curvature, Consist of an amendment processing process which carries out amendment processing of the configuration of the mirror plane piece corresponding to the specific optical functional side of a molding die according to the above-mentioned amendment configuration, and a forming cycle which fabricates by the mirror plane piece by which amendment processing was carried out.
[0009]
[Function] In each lens height of a design configuration, the amount of focal gaps of the direction of an optical axis in the image surface carries out proportionally [ outline ] near the design configuration at the partial curvature of the configuration error of a lens side. According to the above-mentioned configuration, using a parameter called the high partial curvature of this optical property and correlation, since the amendment configuration of an optical functional side is computed, the high mirror plane piece amendment of the precision on optical-character ability is attained.

[0010]
[Embodiment 1] (It corresponds to claim 2) An embodiment 1 is performing from the above-mentioned lens height calculation process to a forming cycle repeatedly, when the above-mentioned focal gap measurement process is performed using the optical element which consists of the above-mentioned forming cycle and this does not fulfill the target.
[Function] Shaping of a lens with a high precision is attained by carrying out repeatedly by 1 time of the forming cycle, by this, even when the optical-character ability of a lens is not enough.
[0011]
[Embodiment 2] The lens height whose embodiment 2 is the location of the main scanning direction where the above-mentioned lens height calculation process intersects the optical functional side of specification [ a chief ray ] by two or more deflection angles by optical simulation beforehand, (It corresponds to claim 3) It asks for the image quantity which is the location of the main scanning direction which intersects the image surface, and this distribution is approximated to models, such as a polynomial, that multiplier is memorized, and it is computing the lens height corresponding to the image quantity which is an input by solving a polynomial.
[Function] It is not necessary to perform an optical simulation by this each time, and the lens height corresponding to image quantity can be found by 1 time of the optical simulation.
[0012]
[Embodiment 3] The above-mentioned sensibility calculation process beforehand an embodiment 3 (It corresponds to claim 4) By optical simulation A configuration error is made to superimpose only on a specific optical functional side. By two or more deflection angles Image quantity, It asks for the amount of focal gaps of the direction of an optical axis, and the partial curvature of the flux of light passage part in a specific optical functional side. The division of the amount of focal gaps is done with partial curvature, and it asks for the sensibility of the amount of focal gaps per unit curvature, and distribution of image quantity and sensibility is approximated to function models, such as a polynomial, the multiplier is memorized, and it is what computes the sensibility corresponding to the image quantity which is an input by solving a function model.
[Function] It is not necessary to perform an optical simulation by this each time, and can ask for the sensibility corresponding to image quantity by 1 time of the optical simulation.
[0013]
[Embodiment 4] As for an embodiment 4, the above-mentioned amendment configuration calculation process approximates distribution of lens height and the partial curvature of the direction of vertical scanning to a function model. (It corresponds to claim 5) It is what consists of a configuration calculation process of memorizing the multiplier, asking for partial curvature by solving a function model from the location of the main scanning direction in two or more points of an optical functional side, and finding height by solving the formula of the radii function which has the above-mentioned partial curvature from the location of the direction of vertical scanning.
[0014]
[Embodiment 5] (It corresponds to claim 6) For an embodiment 5, the above-mentioned amendment configuration calculation process is distribution of lens height and the partial curvature of vertical scanning.

$$C_s = \sum_{i=0}^{n} C_{si} x^i$$

Resemble the becoming polynomial and this multiplier Csi should be.

$$z(x,y) = \sum_{i=0}^{n} \frac{C_{si}}{2} x^i y^2$$

It is what computes the amendment configuration in the point of arbitration by solving the becoming formula.
[0015]

[Embodiment 6] (It corresponds to claim 7) An embodiment 6 is what the above-mentioned amendment configuration calculation process becomes from the modeling process which resembles a function model to distribution of lens height and the partial curvature of a main scanning direction, integrates with a function model twice, and memorizes the multiplier, and the configuration calculation process of find height by solve a function model from the location of the main scanning direction in two or more points of an optical functional side.
[0016]
[Embodiment 7] A numerical-integration process [ as opposed to / as for an embodiment 7, the above-mentioned amendment configuration calculation process performs numerical integration twice to distribution of lens height and the partial curvature of a main scanning direction, and / distribution of lens height and height ], (It corresponds to claim 8) It is what consists of a modeling process which approximates this to a function model and memorizes the multiplier, and a configuration calculation process of finding height by solving a function model from the location of the main scanning direction in two or more points of an optical functional side.
[Function] An amendment configuration which it becomes unnecessary to carry out a new optical simulation and the design of an optical functional side, and offsets the amount of focal gaps of optical equipment by the configuration of embodiments 4-7 is computable. Moreover, since the design formula of a toric side is used, in amendment configuration calculation, amendment processing can be performed only by changing a part of multiplier of a design formula.
[0017]
[Solution means 2] (It corresponds to claim 9 and claim 10) The solution means 2 is at least one optical functional side's being an abbreviation flat surface, and making this field into the above-mentioned specific optical functional side about the optical element created by the manufacture approach of the optical element for light-scanning equipments of the solution means 1 (the above-mentioned embodiment 1 thru/or an embodiment 7 are included).
[0018]
[Solution means 3] (It corresponds to claim 11) The solution means 3 is using the optical element of the above-mentioned solution means 2 about light-scanning equipment.
[0019]
[Solution means 4] (It corresponds to claim 12) the solution means 4 -- plastics injection molding -- public funds -- about the program which creates NC data for processing the mirror plane piece corresponding to the optical functional side of a mold with a NC machining machine The measurement result of the amount of focal gaps in two or more image quantities which can be set to the image surface of light-scanning equipment is used as input data. A lens height calculation means to compute the lens height of the specific optical functional side corresponding to the image quantity of arbitration, A lens height calculation means to compute the sensibility which is the partial curvature of a specific optical functional side and the proportionality coefficient of the amount of focal gaps corresponding to the image quantity of arbitration, It is having constituted from an amount of focal gaps, a partial curvature calculation means computing partial curvature from sensibility, and lens height and an amendment configuration calculation means computing NC data for amendment processing of a specific mirror plane piece from distribution of partial curvature.
[Function] NC data for amendment processing can be created almost automatically from the measurement data of the amount of focal gaps by this configuration.
[0020]
[The gestalt 1 of operation] (Operation gestalt of invention concerning claim 1) These people have already propose "the lens side configuration evaluation approach and configuration evaluation equipment" which can presume the amount of focal gaps in the image surface of light scanning equipment with high precision from the configuration error of an optical functional side by carry out through partial curvature (application for patent No. 132571 [ 2000 to ]). It is shown that it is in abbreviation proportionality when the partial curvature [ in / on the optical functional side of arbitration and / in this / the lens height of arbitration ] of a flux of light band pass and the amount of focal gaps in the image surface corresponding to it have a small configuration error. By moreover, optical simulation By calculating the partial curvature in each lens height, and the image quantity and the amount of focal gaps corresponding to it at the time of making a minute configuration error superimpose on

an optical functional side By showing that the sensibility which is the proportionality coefficient of the amount of focal gaps per [ to each lens height ] unit curvature is computable, solving this about two or more images quantity, searching for distribution of lens height and sensibility, resembling a polynomial etc., and memorizing the multiplier It is shown that the amount of focal gaps in the image surface can be presumed from the configuration measurement result of an optical functional side about the sample of arbitration. moreover, since it could consider that the relation of the amount of focal gaps in the configuration error and the image surface of each optical functional side was abbreviation independence to the configuration error of other optical functional sides, by accumulating the amount of focal gaps by the configuration error of each optical functional side in the image surface showed that evaluation of the amount of focal gaps of the whole optical system was realizable. Invention concerning this application follows this approach from reverse. That is, the amount of focal gaps in each image quantity of light-scanning equipment is surveyed, an amendment configuration which offsets a focal gap in a specific optical functional side from this measurement result is generated, and the curvature of field of the whole optical system is decreased by carrying out amendment processing of the mirror plane piece according to it. Although the flow of this processing is shown in drawing 1 , each process in this processing flow is as follows.

[0021] 1. Create metal mold by the conventional approach to the initial shaping **** beginning, and carry out injection-molding processing of the optical element. At this time, a process condition is scrutinized enough and packed so that the configuration of mold goods may be stabilized and it can be processed in the same configuration.

[0022] 2. Include measurement, next the optical element of the amount of focal gaps in light-scanning equipment, and survey the amount of focal gaps. This fixes a polygon mirror, puts the beam measuring device of a laser light source on a direct-acting stage etc., and it performs it by measuring the diameter of a spot of the flux of light, making it scan in the direction of an optical axis. The beam measuring device of a laser light source measures the beam profile of the flux of light irradiated in the specific field, it is equipment which outputs the diameter of a spot of a main scanning direction and the direction of vertical scanning etc., and the beam scan of a photon company etc. is marketed. Thereby, distribution of the diameter of a spot of the deflection from the image surface in each image quantity, horizontal scanning, and the direction of vertical scanning can be found. The amount of focal gaps of each image quantity is calculated by approximating this with a secondary function etc. and calculating the minimum value. Thereby, distribution of the amount of focal gaps of image quantity, a main scanning direction, and each direction of vertical scanning can be found.

[0023] 3. Find the lens height corresponding to calculation of lens height, next each image quantity which calculated the amount of focal gaps in the specific optical functional side. This searches for distribution of image quantity and lens height in optical simulation beforehand, it approximates this to a function, memorizes that multiplier, and searches for it by solving this function.

[0024] 4. Ask for calculation of sensibility, next the sensibility of the partial curvature corresponding to each image quantity which calculated the amount of focal gaps in the specific optical functional side. This also searches for distribution of the sensibility to the partial curvature of image quantity and each optical functional side in optical simulation beforehand. Specifically, processing of the following [ condition / of having given the configuration error only to the specific field ] in a deflection angle is performed. Ask for the image quantity which is the location where the chief ray of the flux of light intersects the image surface, and it asks for the partial curvature chosen by the flux of light approximating the configuration error of the range which passes through a specific optical functional side to the spherical surface or a secondary curve. It asks for the diameter of a spot of horizontal scanning and each vertical scanning in two or more locations near the image surface. The amount of focal gaps obtained by resembling a secondary function etc., respectively and calculating the minimum value is calculated. It asks for the sensibility which is the amount of focal gaps per unit partial curvature by doing the division of the amount of focal gaps of horizontal scanning and each vertical scanning with each partial curvature (refer to the application-for-patent No. 132571 [ 2000 to ] specification for the further detail). And each is approximated to a function and the multiplier is memorized. It asks by solving each function at the time of actual use.

[0025] 5. Ask for amendment partial curvature which offsets the amount of focal gaps of the whole optical system in respect of a specific optical function from calculation, next above-mentioned sensibility and the above-mentioned amount of focal gaps of partial curvature. If this sets dC and the amount of focal gaps to d and

sets sensibility to k for partial curvature, dC will be asked for partial curvature by the following formula.

$$dC = -\frac{d}{k}$$

[0026] 6. Ask the calculation last of an amendment configuration for the amendment configuration of an optical functional side from distribution of horizontal scanning, vertical scanning or both lens height, and amendment partial curvature. By creating the map data within an optical functional side in quest of the multiplier of the model type showing a curved surface, this is outputted in the form which can compute the height in the location of arbitration, in order to create NC data.
[0027] The 1st example of the approach of creating an amendment configuration is shown below. A field where the partial curvature of the direction of vertical scanning changes to a main scanning direction is searched for by solving the following formulas.

$$C_s = f(x)$$

$$z(x, y) = \frac{C_s y^2}{1 + \sqrt{1 - C_s{}^2 y^2}}$$

Therefore, if partial curvature distribution of the direction of vertical scanning can be approximated to the function f (x) Becoming, the amendment configuration of a vertical-scanning configuration can be derived directly. As a function, a polynomial, a spline function, etc. are desirable.
[0028] Next, the 2nd example of the approach of creating an amendment configuration is shown. When this has small partial curvature, partial curvature distribution is integrated with and created using the 2 times partial differential of partial curvature and a configuration becoming almost the same. It considers as the nxsecondary polynomial as shows below the function model of the amendment configuration created this time.

$$z(x, y) = \sum_{j=0}^{2} \sum_{i=0}^{n} e_{ji} x^i y^j$$

The 2 times partial differential of horizontal scanning and the direction of vertical scanning is as follows about this.

$$\frac{\partial^2 z}{\partial x^2} = \sum_{j=0}^{2} \sum_{i=2}^{n} i(i-1) e_{ji} x^{i-2} y^j$$

$$\frac{\partial^2 z}{\partial y^2} = \sum_{j=2}^{2} \sum_{i=2}^{n} j(j-1) e_{ji} x^i y^{j-2} = \sum_{i=0}^{n} 2 e_{2i} x^i$$

Therefore, an amendment configuration can be created by calculating eij from partial curvature distribution of a main scanning direction and the direction of vertical scanning. This will be set to each e2i, if the direction of vertical scanning approximates distribution of lens height and partial curvature to a polynomial of degree n and each multiplier of a polynomial is doubled 0.5. Moreover, a main scanning direction approximates distribution of lens height and partial curvature to the n-secondary polynomial, and computes each e0i by integrating with this twice. Since the height in the point of arbitration can be found when creating NC data for amendment

processing of a mirror plane piece, the amendment configuration in a specific optical functional side which offsets the configuration error of the whole optical system can be found.
[0029] Next, the 3rd example of the approach of creating an amendment configuration is shown. Especially this is a means to compute an amendment configuration from distribution of the partial curvature of a main scanning direction. First, numerical integration of the distribution of lens height and partial curvature is carried out twice. Thereby, distribution of lens height and an amendment configuration is searched for. This is approximated to a suitable function model. By carrying out like this, the function model of arbitration other than the polynomial model in design formulas, such as a spline function and a trigonometric function, can be used.
[0030] Here, since an amendment configuration is created using an integral, the effect of the measurement error of a focal distance etc. will be accumulated in many cases. Therefore, when the magnitude of the whole amendment configuration becomes large too much, it is good to correct the small multiplier of a low degree of effect in partial curvature, and to make it the absolute value of an amendment configuration become small.
[0031] 7. Create the mirror plane piece of metal mold based on the configuration of a new optical functional side where the amendment configuration drawn by the approach beyond amendment processing was made to superimpose on a design configuration. When using free sculptured surface processing machines into which a configuration is processed absolutely, such as cutting and grinding, after making an amendment configuration superimpose on a design configuration, by the conventional approach, NC data for processing of a mirror plane piece are created, and it is processed based on this. By polish processing, it is processed by reversing positive/negative of similarity deformation and the height direction for an amendment configuration as it is, and creating NC data with the processing machine which can specify the relative amounts of removal, such as an approach which a front face is made to scan.
[0032] 8. Perform injection molding at this shaping last by the same process condition as the above-mentioned initial shaping. Although all optical functional sides have deflection from the design configuration by this, when carried in light-scanning equipment, the amount of focal gaps is set to about 0 except for a dispersion component.
[0033]
[The operation gestalt of the embodiment 1 of the solution means 1] This operation gestalt is an operation gestalt of invention concerning claim 2. Even if it develops an optical element at the above-mentioned process, at once, the amount of focal gaps is not completely set to 0 for the measurement error of the amount of focal gaps, the processing error of a mirror plane piece, and the error by shaping. Here, the above-mentioned amount measurement process of focal gaps is performed using the created optical element, and it evaluates whether the target engine performance as light-scanning equipment is filled. Here, when the engine performance does not fulfill the target, the engine performance needed can be filled by carrying out by repeating the manufacture approach of the multiple-times above-mentioned until it fulfills a target.
[0034]
[The operation gestalt of the solution means 2] This operation gestalt is an operation gestalt of invention concerning claim 9 and claim 10. although it is the selection approach of "a specific optical functional side" -- this -- horizontal scanning and each vertical scanning -- it is good to choose the field where sensibility is low on the whole. Since an amendment configuration becomes large, the field where sensibility is low is because it becomes small absolutely influencing the processing equipment of a mirror plane piece of precision. Usually, since the optical functional side where sensibility is small does not have horizontal scanning and vertical scanning in scan optical system in many cases, it is good to change the field amended by horizontal scanning and vertical scanning in that case, and to correct 2nd [ a total of ] page. Moreover, it is good to amend only by amendment of one mirror plane piece to make the 1st [ at least ] page into a flat surface within scan optical system. Especially the parallel plate is added and designed and the optical element is created with injection molding. It is good for this to set horizontal scanning and vertical scanning in the location near the image surface in order for sensibility not to become large. And an amendment configuration is created using this flat surface, and amendment processing of this mirror plane piece is carried out. Compared with carrying out amendment processing of the optical functional side which is a curved surface from the first, it is easy to process it to process the amendment configuration of several micrometers to dozens of micrometers to a flat surface, and it can also process precision highly. Moreover, a high precision free sculptured surface processing machine is a very expensive machine tool with the large processing stroke of the height direction, can be boiled

without using this and can overly use the small processing machine of a processing stroke more. Thereby, the amount of focal gaps of light-scanning equipment can be amended more to high degree of accuracy about one optical functional side only by correction of the mirror plane piece which is an abbreviation flat surface.
[0035]
[The operation gestalt of the solution means 4] This operation gestalt is an operation gestalt of invention concerning claim 12. Here, calculation to all calculation of an amendment configuration of the above-mentioned lens height can be realized as software, such as PC. Therefore, a series of processings can be performed one by one by the ability considering the measurement result of the amount of focal gaps as an input, and the software which outputs NC data for amendment processing can be created.
[0036]
[Effect of the Invention] It will be as follows if an effect of the invention is arranged for every invention concerning the main claims.
1. The light-scanning equipment created by the plastics optical element created using the approach of effect-of-the-invention this invention concerning claim 1 can set the amounts of focal gaps other than dispersion to about 0, and makes it possible to offer the light-scanning equipment of high performance. Moreover, since the effect of refractive-index distribution will also be amended to coincidence in order to perform amendment processing based on the actual measurement of the amount of focal gaps of light-scanning equipment, though refractive-index distribution remains to the optical element, the engine performance of light-scanning equipment is not affected. Moreover, since this can be amended using the optical functional side which surveys the amount of focal gaps and has allowances in process tolerance even if there is a case so that the precision prescribe of the configuration of the specific optical functional side of optical system may exceed process tolerance, manufacture of the optical element for light-scanning equipments especially with a small beam diameter is possible, and it is effective on industry. Moreover, since a comprehensive precision of the lens itself is evaluated and a mirror plane piece is amended, even if it may not go into tolerance in respect of being independent, amendment processing stored in tolerance in a comprehensive precision is attained, and lens shaping with a high precision is attained.
[0037] 2. By using the approach of effect-of-the-invention this invention concerning claim 2, it becomes possible to manufacture the optical element for light-scanning equipments which fully fills the target engine performance.
[0038] 3. By using the approach of effect-of-the-invention this invention concerning claim 3, the need of performing optical simulation each time is lost, and processing in a short time is attained more.
[0039] 4. the effect of the invention concerning claim 5 -- this enables it to create the configuration of an optical functional side which offsets the amount of focal gaps of optical equipment, even if it newly carries out neither optical simulation nor the design of an optical functional side.
[0040] 5. The same effectiveness as invention concerning effect-of-the-invention claim 5 concerning claim 6 is produced, and since this is a part of design formula of the above-mentioned special toric side, on the occasion of calculation of an amendment configuration, and creation of NC data, it can perform amendment processing only by changing a part of multiplier of a design formula, and can create NC data for a short period of time.
[0041] 6. Even if it does not use the super-high-degree-of-accuracy free sculptured surface processing machine which produces the same effectiveness as invention concerning effect-of-the-invention claim 1 concerning claim 10, and has still more sufficient operating range, amendment of a curvature of field can be attained and the processing cost of a mirror plane piece can be reduced.
[0042] 7. By effect-of-the-invention this invention concerning claim 12, from the measurement data of the amount of focal gaps, since NC data for amendment processing can be created almost automatically, a designer's artificial mistake etc. can be decreased and amendment can be performed for a short period of time.

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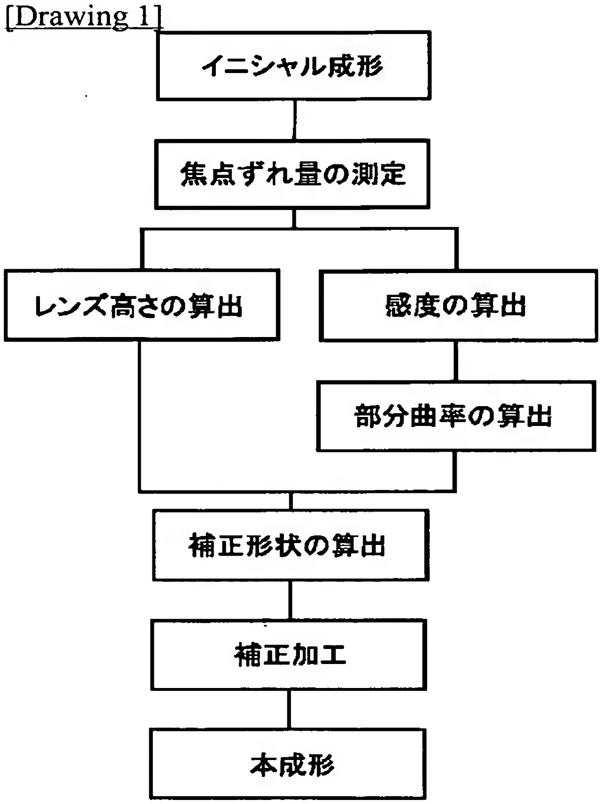
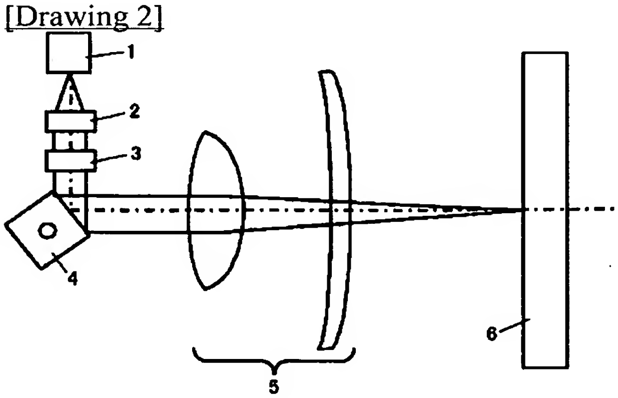
[Translation done.]

## DRAWINGS

[Drawing 1]




[Drawing 2]




[Translation done.]

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| 11/255 | | G02B　3/00 | Z | |

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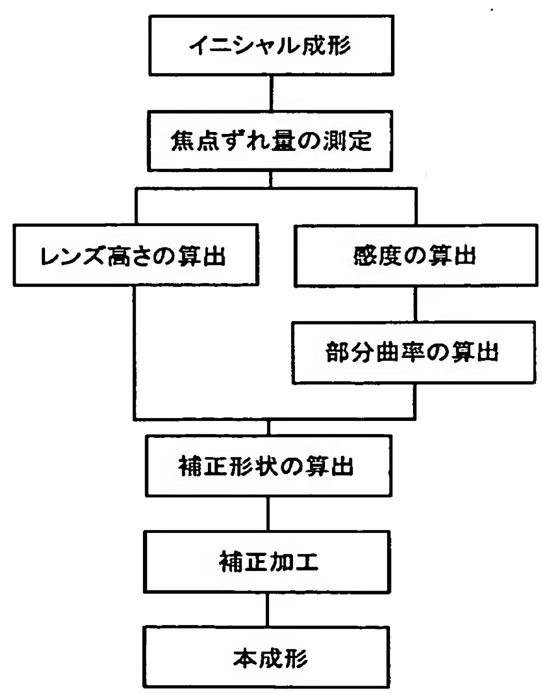
(54)【発明の名称】　光学素子とその製造方法及び光走査装置

(57)【要約】　（修正有）

【課題】像面での焦点ずれによって生じる像面湾曲を小さくする光走査装置用光学素子を、短時間、低コストで製作できるようにする。

【解決手段】射出成形された光学素子を使用時と同等の光走査装置内に取り付け、像面において複数の像高における光軸方向の焦点ずれ量を測定する工程と、複数の像高に対応する特定の光学機能面上の位置を求めるレンズ高さ算出工程と、複数の像高に対応する特定の光学機能面の部分曲率と焦点ずれ量の比例係数である感度を算出する工程と、上記焦点ずれ量と上記感度より特定の光学機能面での部分曲率を求める工程と、上記レンズ高さと部分曲率を基に光学機能面の補正形状を関数モデルの係数またはマップデータとして出力する補正形状算出工程と、上記補正形状にしたがって成形用金型の特定の光学機能面に対応する鏡面駒の形状を補正加工する工程と、補正加工された鏡面駒で成形を行う工程にした。



【特許請求の範囲】

【請求項１】光走査光学系で使用する光学素子を成形にて作成する光学素子の製造方法において、
射出成形された光学素子を使用時と同等の光走査装置内に取り付け、像面において複数の像高における光軸方向の焦点ずれ量を測定する焦点ずれ量測定工程と、
複数の像高に対応する特定の光学機能面上の位置を求めるレンズ高さ算出工程と、
複数の像高に対応する特定の光学機能面の部分曲率と焦点ずれ量の比例係数である感度を算出する感度算出工程と、
上記焦点ずれ量と上記感度より特定の光学機能面での部分曲率を求める部分曲率算出工程と、
上記レンズ高さと部分曲率を基に光学機能面の補正形状を関数モデルの係数またはマップデータとして出力する補正形状算出工程と、
上記補正形状にしたがって成形用金型の特定の光学機能面に対応する鏡面駒の形状を補正加工する補正加工工程と、
補正加工された鏡面駒で成形を行う成形工程とよりなる事を特徴とする光学素子の製造方法。

【請求項２】上記成形工程からなる光学素子を用いて前述の焦点ずれ測定工程を行い、これが目標を満たしていない場合上記レンズ高さ算出工程から成形工程までを繰り返し行う事を特徴する請求項１記載の光学素子の製造方法。

【請求項３】上記レンズ高さ算出工程が、予め光学シミュレーションにより複数の偏向角で主光線が特定の光学機能面と交叉する主走査方向の位置であるレンズ高さと、像面と交叉する主走査方向の位置である像高とを求め、この分布を多項式等のモデルに近似してその係数を記憶しておき、入力である像高に対応するレンズ高さを、多項式を解く事により算出する事を特徴とする請求項１または請求項２の光学素子の製造方法。

【請求項４】上記感度算出工程が、予め光学シミュレーションにより、特定の光学機能面のみに形状誤差を重畳させ、複数の偏向角で像高と、光軸方向の焦点ずれ量と、特定の光学機能面における光束通過部分の部分曲率とを求め、焦点ずれ量を部分曲率で除算して単位曲率当たりの焦点ずれ量の感度を求め、像高と感度の分布を多項式等の関数モデルに近似してその係数を記憶しておき、入力である像高に対応する感度を、関数モデルを解く事により算出する事を特徴とする請求項１乃至請求項３の光学素子の製造方法。

【請求項５】上記補正形状算出工程が、レンズ高さと副走査方向の部分曲率の分布を関数モデルに近似し、その係数を記憶し、光学機能面の複数の点においてその主走査方向の位置から関数モデルを解く事により部分曲率を求め、副走査方向の位置から前述の部分曲率をもつ円弧関数の式を解く事により高さを求める形状算出工程からなる事を特徴とする請求項１乃至請求項４の光学素子の製造方法。

【請求項６】上記補正形状算出工程が、レンズ高さと副走査の部分曲率の分布を

$$C_s = \sum_{i=0}^{n} C_{si} x^i$$

なる多項式に近似し、この係数Ｃsiを用いて

$$z(x, y) = \sum_{i=0}^{n} \frac{C_{si}}{2} x^i y^2$$

なる式を解く事により任意の点における補正形状を算出する事を特徴とする請求項１乃至請求項４の光学素子の製造方法。

【請求項７】上記補正形状算出工程が、レンズ高さと主走査方向の部分曲率の分布に対して関数モデルに近似し、関数モデルを２回積分してその係数を記憶するモデル化工程と、光学機能面の複数の点においてその主走査方向の位置から関数モデルを解く事により高さを求める形状算出工程からなる事を特徴とする請求項１乃至請求項６の光学素子の製造方法。

【請求項８】上記補正形状算出工程が、レンズ高さと主走査方向の部分曲率の分布に対して数値積分を２回行い、レンズ高さと高さの分布に対する数値積分工程と、これを関数モデルに近似してその係数を記憶するモデル化工程と、光学機能面の複数の点においてその主走査方向の位置から関数モデルを解く事により高さを求める形状算出工程からなる事を特徴とする請求項１乃至請求項６の光学素子の製造方法。

【請求項９】請求項１乃至請求項８の光走査装置用光学素子の製造方法により作成された事を特徴とする光学素子。

【請求項１０】少なくとも１つの光学機能面が略平面であり、この面を上記特定の光学機能面とする事を特徴とする請求項９の光学素子。

【請求項１１】請求項９および請求項１０の光学素子を使用する事を特徴とする光走査装置。

【請求項１２】プラスチック射出成形用金型の光学機能面に対応する鏡面駒をＮＣ加工機で加工するためのＮＣデータを作成するプログラムであって、光走査装置の像面における複数の像高での焦点ずれ量の測定結果を入力データとして、任意の像高に対応する特定の光学機能面のレンズ高さを算出するレンズ高さ算出手段と、任意の像高に対応する特定の光学機能面の部分曲率と焦点ずれ量の比例係数である感度を算出するレンズ高さ算出手段

と、焦点ずれ量と感度から部分曲率を算出する部分曲率算出手段と、レンズ高さと部分曲率の分布より特定の鏡面駒の補正加工用ＮＣデータを算出する補正形状算出手段とからなる事を特徴とするＮＣ作成プログラム。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、光学素子とその製造方法、特に光走査装置用光学素子に関するものであり、デジタルコピアやレーザプリンタの光書き込み装置における光学素子の評価に利用して有効なものである。

【０００２】

【従来技術】レーザ光源と多面体鏡を用いた光走査装置は、デジタルコピアやレーザプリンタに用いられる。図２に光走査装置の一例を示す。半導体レーザ等の光源１から出射した光束はコリメータレンズ２を透過して平行光束となり、円筒面レンズ３を透過して多面体鏡４の反射面上で線状に集光される。多面体鏡の回転に応じて反射、偏向された光束は走査光学系５を透過して像面６に設置された感光体表面で集光する。ここで、多面体鏡により光束を偏向する方向を主走査方向、主走査方向と光軸方向に直交する方向を副走査方向、各光学機能面における主走査方向の位置をレンズ高さ、像面における主走査方向の位置を像高と記述する。近年の高画質化の要求と、低コスト化の為に走査光学系の光学素子の数を減らしたいという要求にこたえる為、走査光学系の光学素子の光学機能面の形状は、自由度の高い曲面を用いる様になってきた。特に主走査方向には非球面を、副走査方向には曲率が主走査方向によって変化するような特殊なトーリック面を用いる事が多くなってきた。以下にその一例を示す。

$$z(x,y)=\frac{Cx^2}{1+\sqrt{1-(1+k)C^2x^2}}+\sum_{j=0}^{m}\sum_{i=0}^{n}e_{ji}x^iy^j$$

ここで、ｘは主走査方向の座標、ｙは副走査方向の座標、ｚは光軸方向の座標、ｃは主走査方向の曲率、ｋは円錐定数、ｅｊｉは多項式の係数である。超精密自由曲面加工機の実用化によって、光学機能面にこのような自由度の高い面を採用できるようになった。

【０００３】走査光学系の各光学機能面の有効範囲は、主走査方向に数十ｍｍから数百ｍｍにあるのに対して副走査方向には十ｍｍ前後と偏平している。このような光学素子をプラスチック射出成形等で作成する場合、樹脂の不均一な収縮などの影響により設計値からの偏差（以下これを「形状誤差」と呼ぶ）が発生する。樹脂の収縮率はおおむね０．７％程度であるから、光学機能面の設計形状から射出成形用の鏡面駒を作成するに当たって、従来は理論的または経験的に求めた収縮率で相似拡大した形状に加工していた。しかし、光学機能面が数百ｍｍと大きいので、樹脂の非線形な収縮による光学機能面の形状誤差は数μｍから数十μｍとなり、これが光学系の性能に大きく影響する。

【０００４】成形品の形状誤差を小さくする方法の１つとして、特開平５－９６５７２号公報や特開平７－６０８５７号公報に記載されているように成形品の形状を測定し、形状誤差を求め、これを相殺するように成形型の鏡面駒を補正する方法がある。しかしこれでは全ての光学機能面に対応する鏡面駒を形状誤差が十分小さくなるまで補正する必要がある。

【０００５】また、プラスチック射出成形で作成したレンズの特徴として、屈折率分布の問題（参考文献：特開平１０－２８８７４９号公報、特開平１１－７７８４２号公報）がある。これは樹脂内の屈折率の不均一な分布がレンズ効果を生み、光学系の焦点位置を変化させてしまう現象で、これを回避する為に設計に工夫をしたり成形後に屈折率分布を減少させる為の工程を設けたりする必要がある。また、これを０に出来ない限り、全ての光学素子を設計値通りの形状に作成しても、光走査装置としては焦点位置のずれによる像面湾曲により光学性能の劣化を生じてしまう。

【０００６】特に、像面におけるスポット径を小さくして、高密度の光書き込み装置の走査光学系を作成する場合、スポット径は光学系のＦナンバーに略比例するので光学系のＦナンバーを小さくする必要があるが、同時にスポット径の２乗に略比例して焦点深度が狭くなってしまう。したがってスポット径の小さい光走査装置を開発する為には、像面での焦点ずれによって生じる像面湾曲を十分に小さくする必要が有り、これが高密度の光走査装置の実現への大きな技術課題となっている。

【０００７】

【解決しようとする課題】そこで、この発明は、像面での焦点ずれによって生じる像面湾曲を十分に小さくできるようにして、像面湾曲の小さいの光走査装置用光学素子を、短時間、低コストで製作できるように、その製造方法及び製造装置を工夫することをその課題とするものである。

【０００８】

【課題解決のために講じた手段】

【解決手段１】（請求項１に対応）解決手段１は、光走査光学系で使用する光学素子を成形にて作成する光学素子の製造方法を前提にして、次の工程から構成されるものである。射出成形された光学素子を使用時と同等の光走査装置内に取り付け、像面において複数の像高における光軸方向の焦点ずれ量を測定する焦点ずれ量測定工程と、複数の像高に対応する特定の光学機能面上の位置を求めるレンズ高さ算出工程と、複数の像高に対応する特

定の光学機能面の部分曲率と焦点ずれ量の比例係数である感度を算出する感度算出工程と、上記焦点ずれ量と上記感度より特定の光学機能面での部分曲率を求める部分曲率算出工程と、上記レンズ高さと部分曲率を基に光学機能面の補正形状を関数モデルの係数またはマップデータとして出力する補正形状算出工程と、上記補正形状にしたがって成形用金型の特定の光学機能面に対応する鏡面駒の形状を補正加工する補正加工工程と、補正加工された鏡面駒で成形を行う成形工程とよりなること。

【０００９】

【作用】設計形状の各レンズ高さにおいて、像面における光軸方向の焦点ずれ量が設計形状近傍ではレンズ面の形状誤差の部分曲率に概略比例する。上記構成によれば、この光学特性と相関の高い部分曲率というパラメータを用い、光学機能面の補正形状を算出しているので光学性能上の精度が高い鏡面駒補正が可能となる。

【００１０】

【実施態様１】（請求項２に対応）実施態様１は、上記成形工程からなる光学素子を用いて前述の焦点ずれ測定工程を行い、これが目標を満たしていない場合上記レンズ高さ算出工程から成形工程までを繰り返し行うことである。

【作用】これにより１回の成形工程でレンズの光学性能が十分でない場合でも、繰り返し行うことで精度が高いレンズが成形可能となる。

【００１１】

【実施態様２】（請求項３に対応）実施態様２は、上記レンズ高さ算出工程が、予め光学シミュレーションにより複数の偏向角で主光線が特定の光学機能面と交叉する主走査方向の位置であるレンズ高さと、像面と交叉する主走査方向の位置である像高とを求め、この分布を多項式等のモデルに近似してその係数を記憶しておき、入力である像高に対応するレンズ高さを、多項式を解く事により算出することである。

【作用】これにより毎回光学シュミレーションを行う必要がなく、１回のみの光学シュミレーションで像高に対応するレンズ高さを求めることができる。

【００１２】

【実施態様３】（請求項４に対応）実施態様３は、上記感度算出工程が、予め光学シミュレーションにより、特定の光学機能面のみに形状誤差を重畳させ、複数の偏向角で像高と、光軸方向の焦点ずれ量と、特定の光学機能面における光束通過部分の部分曲率とを求め、焦点ずれ量を部分曲率で除算して単位曲率当たりの焦点ずれ量の感度を求め、像高と感度の分布を多項式等の関数モデルに近似してその係数を記憶しておき、入力である像高に対応する感度を、関数モデルを解く事により算出するものであることである。

【作用】これにより毎回光学シュミレーションを行う必要がなく、１回のみの光学シュミレーションで像高に対応する感度を求めることができる。

【００１３】

【実施態様４】（請求項５に対応）実施態様４は、上記補正形状算出工程が、レンズ高さと副走査方向の部分曲率の分布を関数モデルに近似し、その係数を記憶し、光学機能面の複数の点においてその主走査方向の位置から関数モデルを解く事により部分曲率を求め、副走査方向の位置から前述の部分曲率をもつ円弧関数の式を解く事により高さを求める形状算出工程からなるものであることである。

【００１４】

【実施態様５】（請求項６に対応）実施態様５は、上記補正形状算出工程が、レンズ高さと副走査の部分曲率の分布を

$$C_s = \sum_{i=0}^{n} C_{si} x^i$$

なる多項式に近似し、この係数Ｃｓｉをいて

$$z(x, y) = \sum_{i=0}^{n} \frac{C_{si}}{2} x^i y^2$$

なる式を解く事により任意の点における補正形状を算出するものであることである。

【００１５】

【実施態様６】（請求項７に対応）実施態様６は、上記補正形状算出工程が、レンズ高さと主走査方向の部分曲率の分布に対して関数モデルに近似し、関数モデルを２回積分してその係数を記憶するモデル化工程と、光学機能面の複数の点においてその主走査方向の位置から関数モデルを解く事により高さを求める形状算出工程からなるものであることである。

【００１６】

【実施態様７】（請求項８に対応）実施態様７は、上記補正形状算出工程が、レンズ高さと主走査方向の部分曲率の分布に対して数値積分を２回行い、レンズ高さと高さの分布に対する数値積分工程と、これを関数モデルに近似してその係数を記憶するモデル化工程と、光学機能面の複数の点においてその主走査方向の位置から関数モデルを解く事により高さを求める形状算出工程からなるものであることである。

【作用】実施態様４～７の構成により、新たな光学シュミレーションや、光学機能面の設計をする必要がなくなり、光学装置の焦点ずれ量を相殺するような補正形状を算出することができる。またトーリック面の設計式を利用しているので、補正形状算出において、設計式の係数

の一部を変更するだけで補正加工を行うことができる。

【００１７】

【解決手段２】（請求項９及び請求項１０に対応）解決手段２は、解決手段１（上記実施態様１乃至実施態様７を含む）の光走査装置用光学素子の製造方法により作成された光学素子について、少なくとも１つの光学機能面が略平面であり、この面を上記特定の光学機能面とすることである。

【００１８】

【解決手段３】（請求項１１に対応）解決手段３は、光走査装置について、上記解決手段２の光学素子を使用することである。

【００１９】

【解決手段４】（請求項１２に対応）解決手段４は、プラスチック射出成形用金型の光学機能面に対応する鏡面駒をＮＣ加工機で加工するためのＮＣデータを作成するプログラムについて、光走査装置の像面における複数の像高での焦点ずれ量の測定結果を入力データとして、任意の像高に対応する特定の光学機能面のレンズ高さを算出するレンズ高さ算出手段と、任意の像高に対応する特定の光学機能面の部分曲率と焦点ずれ量の比例係数である感度を算出するレンズ高さ算出手段と、焦点ずれ量と感度から部分曲率を算出する部分曲率算出手段と、レンズ高さと部分曲率の分布より特定の鏡面駒の補正加工用ＮＣデータを算出する補正形状算出手段とから構成したことである。

【作用】この構成により焦点ずれ量の測定データから、ほぼ自動で補正加工用ＮＣデータを作成することができる。

【００２０】

【実施の形態１】（請求項１に係る発明の実施形態）本出願人は、部分曲率を媒介にする事により光学機能面の形状誤差から光走査装置の像面における焦点ずれ量を高精度に推定できる、「レンズ面形状評価方法及び形状評価装置」をすでに提案している（特願２０００－１３２５７１号）。これは、任意の光学機能面において任意のレンズ高さにおける光束通過幅相当の部分曲率と、それに対応する像面での焦点ずれ量は形状誤差が小さい場合は略比例関係にある事を示し、また光学シミュレーションにより、光学機能面に微小な形状誤差を重畳させた時の各レンズ高さにおける部分曲率と、それに対応する像高と焦点ずれ量を求めることにより、各レンズ高さに対する単位曲率当たりの焦点ずれ量の比例係数である感度を算出できる事を示し、これを複数像高について解いてレンズ高さと感度の分布を求め、多項式などに近似してその係数を記憶しておく事により、任意のサンプルについて光学機能面の形状測定結果から像面での焦点ずれ量を推定する事が出来る事を示している。また、各光学機能面の形状誤差と像面における焦点ずれ量の関係は他の光学機能面の形状誤差に対して略独立とみなせるので、像面において各光学機能面の形状誤差による焦点ずれ量を積み上げる事により光学系全体の焦点ずれ量の評価が実現できる事を示した。この出願に係る発明はこの方法を逆からたどるものである。すなわち、光走査装置の各像高における焦点ずれ量を実測し、この測定結果から特定の光学機能面において焦点ずれを相殺するような補正形状を生成し、それにしたがって鏡面駒を補正加工する事により光学系全体の像面湾曲を減少させる。図１に、この処理の流れを示しているが、この処理フローにおける各工程は次のとおりである。

【００２１】１．イニシャル成形

まず最初に従来の方法で金型を作成し、光学素子を射出成形加工する。この時、成形品の形状が安定して同じ形状で加工できるように成形条件を十分精査してつめておく。

【００２２】２．焦点ずれ量の測定

次に、光学素子を光走査装置に組み込み、焦点ずれ量を実測する。これは、ポリゴンミラーを固定して、レーザ光源のビーム測定装置を直動ステージなどに載せ、光軸方向に走査させつつ光束のスポット径を測定する事により行う。レーザ光源のビーム測定装置は特定の面内に照射された光束のビームプロファイルを測定し、主走査方向、副走査方向のスポット径等を出力する装置で、フォトン社のビームスキャン等が市販されている。これにより各像高における像面からの偏差と主走査、副走査方向のスポット径の分布が求まる。これを２次関数などで近似してその最小値を求める事により各像高の焦点ずれ量を求める。これにより像高と主走査方向、副走査方向それぞれの焦点ずれ量の分布が求まる。

【００２３】３．レンズ高さの算出

次に、特定の光学機能面において焦点ずれ量を求めた各像高に対応するレンズ高さを求める。これは予め光学シミュレーションで像高とレンズ高さの分布を求め、これを関数に近似してその係数を記憶しておき、この関数を解く事により求める。

【００２４】４．感度の算出

次に、特定の光学機能面において焦点ずれ量を求めた各像高に対応する部分曲率の感度を求める。これも予め光学シミュレーションで像高と各光学機能面の部分曲率への感度の分布を求める。具体的には、特定の面のみに形状誤差を与えた状態で偏向角で以下の処理を行う。光束の主光線が像面と交叉する位置である像高を求め、光束が特定の光学機能面を通過する範囲の形状誤差を球面または２次曲線に近似して選ばれた部分曲率を求め、像面近傍の複数の位置で主走査、副走査それぞれのスポット径を求め、それぞれ２次関数などに近似してその最小値を求める事で得られる焦点ずれ量を求め、主走査、副走査それぞれの焦点ずれ量をそれぞれの部分曲率で除算する事により単位部分曲率当たりの焦点ずれ量である感度を求める（さらなる詳細は特願２０００－１３２５７１

号明細書を参照されたい）。そしてそれぞれを関数に近似してその係数を記憶しておく。実際の使用時にはそれぞれの関数を解く事により求める。

【００２５】５．部分曲率の算出
次に前述の感度と焦点ずれ量から特定の光学機能面で光学系全体の焦点ずれ量を相殺するような補正部分曲率を求める。これは部分曲率をｄＣ、焦点ずれ量をｄ、感度をｋとすると、部分曲率をｄＣは次の式により求められる。

$$dC = -\frac{d}{k}$$

【００２６】６．補正形状の算出
最後に、主走査、副走査のいずれかまたは両方のレンズ高さと補正部分曲率の分布より光学機能面の補正形状を求める。これは曲面を示すモデル式の係数を求めるか、光学機能面内のマップデータを作成する事により、ＮＣデータを作成する為に任意の位置での高さを算出可能な形で出力する。

【００２７】以下に補正形状を作成する方法の第１の実施例を示す。副走査方向の部分曲率が主走査方向に変化するような面は、以下の式を解く事により求められる。

$$C_s = f(x)$$

$$z(x,y) = \frac{C_s y^2}{1+\sqrt{1-C_s{}^2 y^2}}$$

従って、副走査方向の部分曲率分布をｆ（ｘ）なる関数に近似する事が出来れば、副走査形状の補正形状は直接導出する事が出来る。関数としては多項式や、スプライン関数などが好ましい。

【００２８】次に補正形状を作成する方法の第２の実施例を示す。これは、部分曲率が小さい場合は部分曲率と形状の２回偏微分がほぼ同じになることを利用して、部分曲率分布を積分して作成するものである。今回作成する補正形状の関数モデルを以下に示すようなｎ×２次の多項式とする。

$$z(x,y) = \sum_{j=0}^{2}\sum_{i=0}^{n} e_{ji} x^i y^j$$

これを主走査、副走査方向の２回偏微分は以下のようになる。

$$\frac{\partial^2 z}{\partial x^2} = \sum_{j=0}^{2}\sum_{i=2}^{n} i(i-1) e_{ji} x^{i-2} y^j$$

$$\frac{\partial^2 z}{\partial y^2} = \sum_{j=2}^{2}\sum_{i=2}^{n} j(j-1) e_{ji} x^i y^{j-2} = \sum_{i=0}^{n} 2e_{2i} x^i$$

従って、主走査方向と副走査方向の部分曲率分布から$e_{ij}$を求めることにより、補正形状を作成することができる。副走査方向は、レンズ高さと部分曲率の分布をｎ次の多項式に近似して多項式の各係数を０．５倍すると、これが各$e_{2i}$となる。また主走査方向はレンズ高さと部分曲率の分布をｎ－２次の多項式に近似して、これを２回積分することにより各$e_{0i}$を算出する。鏡面駒の補正加工用のＮＣデータを作成する場合に任意の点における高さを求める事が出来るので、光学系全体の形状誤差を相殺するような特定の光学機能面における補正形状が求まる。

【００２９】次に、補正形状を作成する方法の第３の実施例を示す。これは特に主走査方向の部分曲率の分布から補正形状を算出する手段である。まず、レンズ高さと部分曲率の分布を２回数値積分する。これによりレンズ高さと補正形状の分布が求められる。これを適当な関数モデルに近似する。こうする事により、スプライン関数や三角関数など設計式にある多項式モデル以外の任意の関数モデルを使用する事が出来る。

【００３０】ここで、補正形状は積分を用いて作成するので、焦点距離の測定誤差等の影響が積み上げられてしまうことが多い。従って、補正形状全体の大きさが大きくなりすぎた場合は、部分曲率への影響の小さい低次の係数を修正して補正形状の絶対値が小さくなるようにすると良い。

【００３１】７．補正加工
以上の方法で導出された補正形状を設計形状に重畳させた新たな光学機能面の形状を基に金型の鏡面駒を作成する。切削や研削など絶対形状を加工する自由曲面加工機を用いる場合、設計形状に補正形状を重畳させた後、従

来の方法で鏡面駒の加工用ＮＣデータを作成し、これを元に加工をする。研磨加工で、前面に走査させる方法など相対的な除去量を指定できる加工機では、補正形状をそのまま相似変形、高さ方向の正負の反転を行ってＮＣデータを作成し、加工を行う。

【００３２】８．本成形

最後に、前述のイニシャル成形と同一の成形条件で射出成形を行う。これにより全ての光学機能面が設計形状から偏差をもっているにも関わらず、光走査装置に搭載した時には焦点ずれ量は、ばらつき成分を除きほぼ０となる。

【００３３】

【解決手段１の実施態様１の実施形態】この実施形態は、請求項２に係る発明の実施形態である。上記の工程で光学素子を開発しても、焦点ずれ量の測定誤差、鏡面駒の加工誤差、成形による誤差のため、１回では焦点ずれ量は完全に０にはならない。ここで、作成した光学素子を用いて前述の焦点ずれ量測定工程を行い、光走査装置としての目標性能を満たしているかを評価する。ここで、性能が目標を満たしていない場合は、目標を満たすまで複数回前述の製造方法を繰り返して行う事により、必要とされる性能を満たす事ができる。

【００３４】

【解決手段２の実施形態】この実施形態は、請求項９及び請求項１０に係る発明の実施形態である。「特定の光学機能面」の選択方法であるが、これは主走査、副走査それぞれ全体的に感度の低い面を選択するとよい。感度の低い面は補正形状が大きくなるため、鏡面駒の加工装置の絶対精度の影響が小さくなるためである。通常、走査光学系のなかで主走査、副走査共に感度の小さい光学機能面はない場合が多いので、その場合は主走査、副走査で補正する面をかえて、計２面を修正するのが良い。また、１つの鏡面駒の補正のみで補正を行いたい場合は、走査光学系内で少なくとも１面を平面とすると良い。特に平行平板を加えて設計しておき、その光学素子を射出成形によって作成しておく。これが主走査、副走査共に感度が大きくならない為には、像面に近い位置におくと良い。そして、この平面を用いて補正形状を作成し、この鏡面駒を補正加工する。平面に対して数$\mu$mから数十$\mu$mの補正形状を加工する事は、もともと曲面である光学機能面を補正加工するのに比べ、加工が容易であり、精度も高く加工できる。また、高さ方向の加工ストロークの大きい超高精度自由曲面加工機は大変高価な工作機械であり、これを使わずにより加工ストロークの小さな加工機を使用する事が出来る。これにより、１つの光学機能面について、略平面である鏡面駒の修正のみで、より高精度に光走査装置の焦点ずれ量を補正する事が出来る。

【００３５】

【解決手段４の実施形態】この実施形態は、請求項１２に係る発明の実施形態である。ここで、前述のレンズ高さの算出から補正形状の算出まではすべてＰＣ等のソフトウエアとして実現可能である。よって、焦点ずれ量の測定結果を入力として、一連の処理を順次行い、補正加工用のＮＣデータを出力するソフトウエアを作成する事ができる。

【００３６】

【発明の効果】主な請求項に係る発明毎に発明の効果を整理すれば次のとおりである。

１．請求項１に係る発明の効果

本発明の方法を用いて作成したプラスチック光学素子で作成した光走査装置は、ばらつき以外の焦点ずれ量をほぼ０とすることができ、高性能の光走査装置を提供することを可能とする。また、光走査装置の焦点ずれ量の実測値に基づいて補正加工を行う為、屈折率分布の影響も同時に補正する事となるので、光学素子に屈折率分布が残留していたとしても光走査装置の性能に影響を及ぼさない。また、光学系の特定の光学機能面の形状の要求精度が加工精度を上回るような場合が有っても、その焦点ずれ量を実測し、加工精度に余裕のある光学機能面を用いてこれを補正する事が出来るため、特にビーム径が小さい光走査装置用の光学素子の製造が可能であり、産業上有効である。またレンズ自体の総合精度を評価して鏡面駒の補正を行うので、単独の面で公差に入らない場合があっても、総合精度で公差内に収める補正加工が可能となり、精度の高いレンズ成形が可能となる。

【００３７】２．請求項２に係る発明の効果

本発明の方法を用いる事により、十分に目標性能を満たす光走査装置用光学素子を製造する事が可能となる。

【００３８】３．請求項３に係る発明の効果

本発明の方法を用いる事により、毎回光学シミュレーションを行う必要が無くなり、より短時間での処理が可能になる。

【００３９】４．請求項５に係る発明の効果

これにより、新たに光学シミュレーションや、光学機能面の設計をしなくても、光学装置の焦点ずれ量を相殺するような光学機能面の形状を作成する事が可能になる。

【００４０】５．請求項６に係る発明の効果

請求項５に係る発明と同じ効果を生じ、また、これは前述の特殊なトーリック面の設計式の一部であるから、補正形状の算出とＮＣデータの作成に際して、設計式の係数の一部を変更するだけで補正加工を行うことができ、ＮＣデータの作成を短期間で行う事が出来る。

【００４１】６．請求項１０に係る発明の効果

請求項１に係る発明と同じ効果を生じ、さらに、十分な動作範囲をもつ、超高精度自由曲面加工機を使わなくとも、像面湾曲の補正が可能となり、鏡面駒の加工コストを減らす事が出来る。

【００４２】７．請求項１２に係る発明の効果

本発明により、焦点ずれ量の測定データから、ほぼ自動

で補正加工用ＮＣデータを作成する事が出来るので、設計者の人為的ミスなどを減少させ、短期間で補正作業を行う事が出来る。

【図面の簡単な説明】

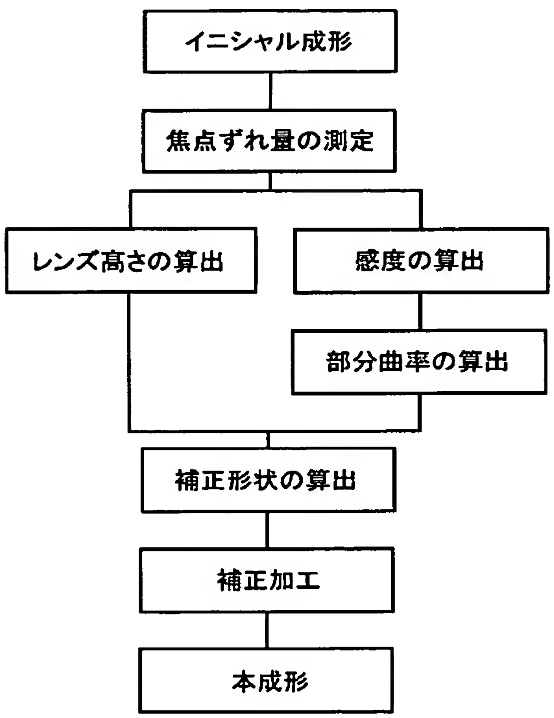
【図１】は光学系全体の像面湾曲を減少させるための処理フロー図である。

【図２】は書き込み装置の模式図である。

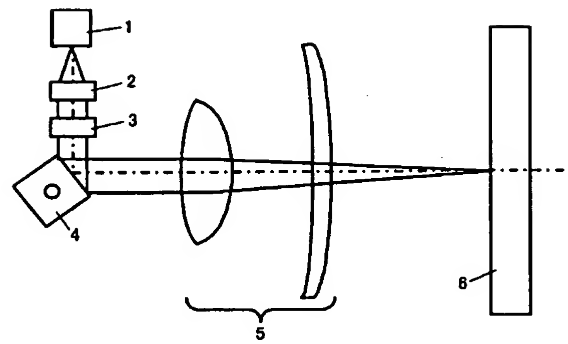
【符号の説明】

１：光源
２：コリメータレンズ
３：円筒面レンズ
４：多面体鏡
５：走査光学系
６：像面

【図１】




【図２】

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